# METHOD OF INCREASING THE SPATIAL RESOLUTION OF TOUCH SENSITIVE DEVICES

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is related to and claims priority to Provisional U.S. Patent Application Ser. No. 60/522,107, filed Aug. 16, 2004, having the same title and inventors as herein, which provisional application is hereby incorporated by reference in its entirety.

## BACKGROUND

[0002] The present invention relates generally to the field of touch sensitive devices, and, in particular, to the field of optimizing capacitive sensing electrode shape and arrangement to increase the effective spatial resolution and/or the physical range of the sensing device using a limited number of sensors.

[0003] In a capacitive touch sensitive device, each sensor, of which there may be many, comprises a conductive pad that forms one plate of a capacitor and a way to measure the capacitance of the conductive pad in conjunction with another movable conductive object. The movable conductive object is typically a finger or stylus that is kept at a minimum distance from the conductive pad by a non-conductive spacer. The two conductive objects (conductive pad and movable conductive object), along with the non-conductive dielectric between them, form a capacitor. As known to those skilled in the art, the capacitance of this capacitor changes as the distance and/or overlap between the objects changes. In a typical device the number of conductive pads (henceforth called electrodes), the size of the electrodes, and the spacing between the electrodes determine the physical range and spatial resolution of the touch sensitive device.

[0004] In typical implementations of capacitive touch sensitive devices the position of a finger gliding over a dielectric-covered array of sensor electrodes is determined by observing the change in capacitance as the finger moves on the surface. Scanning and processing circuitry measures the change in capacitance due to the varying overlap between the finger and a given electrode. If a finger is large enough to partially overlap multiple neighboring electrodes then interpolation allows the finger position to be determined to a resolution much higher than the electrode spacing. The interpolation calculation follows the classic centroid formula: the sum of the signal values at each electrode is multiplied by its coordinate and divided by the sum of all the signal values. This technique works equally well with linear arrays of row and column electrodes, radial arrays of electrodes arranged as spokes in a wheel, or two-dimensional arrays of electrodes arranged to fill a planar space. Special electrode shapes intended to boost interpolation accuracy or resolution are the main distinction between the various related art designs.

[0005] For example, U.S. Pat. No. 5,463,388 to Boie et al., which is hereby incorporated by reference, teaches fingertip sized, interleaved electrode spirals to minimize the number of electrodes needed for a multi-touch sensor array. The interleaving ensures that a finger overlaps multiple electrodes even when centered on a particular electrode and electrodes are one fingertip width apart. Stable interpolation generally requires continual finger overlap with multiple electrodes.

[0006] Seonkyoo Lee, "A Fast Multiple-Touch-Sensitive Input Device," Master's Thesis, University of Toronto (1984) teaches virtual grouping of square electrode cells to more quickly determine whether an object is present within a neighborhood. U.S. Pat. No. 5,767,457 to Gerpheide teaches locating an object by finding the balance point of a virtual grouping of electrodes on either side of the object. Both of these references are hereby incorporated by reference.

[0007] Finally, U.S. Pat. Nos. 5,543,590; 5,543,591; 5,880,411; and 6,414,671; each assigned to Synaptics and hereby incorporated by reference, teach dense interleaving of row and column spanning electrodes in the same plane by shaping each row electrode as a connected string of diamond shapes, and each column electrode as a string of diamond shapes with centers offset from the row diamond centers.

[0008] However, additional improvement in resolution is still desired for such devices. Although resolution may be increased by adding additional sensor elements, dictates of scanning time, circuitry cost, and power consumption simultaneously drive systems towards as few sensor elements as possible. Therefore, there is a need in the art of sensor array design for sensor arrangements that maximize resolution with a limited number of sensors. Disclosed herein is a touch sensitive device that addresses the needs of the prior art for increased resolution and decreased sensor element count.

## SUMMARY

[0009] Disclosed herein is a capacitive touch sensitive device. One aspect of the touch sensitive device described herein is a reduction in the number of sensor circuits needed for circular or linear capacitive touch sensitive devices while maintaining the same resolution and absolute position determination for a single object. A related aspect of the touch sensitive device described herein a coding pattern that allows each sensor circuit of a capacitive touch sensitive device to share multiple electrodes at specially chosen locations in a sensor array such that the ability to determine the absolute position of a single object over the array is not compromised.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0010] **FIG. 1** illustrates a touch sensitive device employing certain teachings of the present invention.

## DETAILED DESCRIPTION

[0011] A capacitive touch sensor is described herein. The following embodiments of the invention are illustrative only and should not be considered limiting in any respect.

[0012] The touch sensitive device described herein allows each sensor circuit to share two or more electrodes by dispersing the shared electrodes in a particular pattern. The electrodes are shared in the sense that they both electrically connect to the same capacitive measuring sensor circuit through a common conductor without the need for multiplexing switches. Preferably, the distance separating a pair of shared electrodes, i.e., the dispersal distance, is one-third the number of electrodes in the device. The touch sensitive